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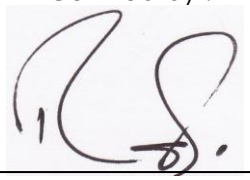

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WATERBOT – A WATERING PLANT ROBOT

MUHAMMAD HAZWAN ZULFADHLI BIN MOHD ZULKIFLI

A Thesis Submitted in Fulfillment of the Requirements
for the Award of the
Bachelor of Engineering (Electrical-Mechatronics)

Faculty of Electrical Engineering
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DEDICATION

Especially dedicated, in thankful appreciation for support, encouragement and with all those sacrifices to my dearest mama,Norhizam Bte Othman and abah, Mohd Zulkifli Bin Mohd Yunus. May all your wishes been granted by God, the Almighty…

Also to the most understanding partner, my beloved Farahiza Izzatie Binti Mohd Rani who always by my side to cheer me up when I was down and to my bestfriend, Mohd Khairul Azizat Bin Johari who add the colours on my canvas of life…

To my siblings, Nur Izzati Maisarah, Nur Izzah Naemah, Mohd Hasif and Nurfarah Adibah, for the love we had and the pain we shared in life together are always on my mind and I hope you will achieve what you are aim for…

And to fellow students, who have encouraged, guided and inspired me throughout my journey of education…

ACKNOWLEGEMENT

Assalamualaikum and great thank to God finally I finish my project on building and designing a watering plant robot named as WaterBot. First and foremost, I would like to express my appreciation and deep respect to my supervisor, Prof. Madya Dr. Rosbi Bin Mamat for the guidance and encouraged he give throughout the progress in completing this project. With his full support, this project finally accomplished as expected from the objective.

Special thanks to my friends that share their idea and advice in completing my project. Their support and encouragement in my project have helped me in various aspects. Without their help, this project would very difficult to complete and it will take a long time to finish.

Finally, thank to my dear family that support me in various field such as fund, idea and moral in completing the project.

I hope that this project able to be a step for an advance watering robot plant in the future because nowadays human uses technology to ease their life.

ABSTRACT

In this modern era, humans are busy chasing success and materials as to have a comfort and fabulous lifestyles. They used to spend too much of their time in working hours and their daily and healthy routines. Some materialistic parents even neglected their spouse or children. More and more people nowadays also neglected the environment they live in and do not bother about their responsibilies towards motherearth.Such as watering plants around the house and others daily routine. Watering crops and landscapes plants needs continuous watering system. Without water, all living things in this planet will die. Thus, designing a robot to replace human and conventional systems in watering domestics uses and to a larger extend in watering vegetable orchards farms can be very important. In Japanese, robots are specially designed for planting, watering and even harvesting farm crops. Crops watering systems in Malaysia are not as advance as in Japan. Robots are not widely used as the main watering technology as it is more usual to use conventional pumps and piping systems. It is widely known that designing, maintaining and implementing robotic technologies are more costly and are not cost effective in small scale applications. Therefore for the scope of this project it is focused on designing a domestic robot for watering vased planted plants only.

ABSTRAK

Pada zaman moden kini, manusia semakin sibuk mengejar kejayaan serta kekayaan didalam dunia supaya memperoleh kehidupan yang senang dan mewah. Mereka menumpukan banyak masa di alam pekerjaan sehinggakan kadang-kala mengabaikan rutin harian mereka. Ada diantara mereka sanggup mengabaikan keluarga hanya semata-mata mengejar kekayaan. Malah juga yang lupa tentang tanggungjawab mereka terhadap alam sekitar. Antaranya seperti menyiram pokok di rumah dan rutin-rutin yang lain. Pokok memerlukan air sebagai asas kehidupan mereka. Tanpa air yang mencukupi, pokok boleh menjadi layu, tidak sihat dan akhirnya mati. Disinilah perlunya sebuah robot yang menyiram pokok supaya dapat mengantikan tugas manusia. Bidang pertanian di Malaysia masih kurang menggunakan robot sebagai salah satu teknologi yang boleh meringankan beban manusia. Jika digunakan dalam bidang pertanian, ia hanya melibatkan konsep penggunaan sistem sahaja dan bukannya robot. Tidak seperti di Jepun, robot diciptakan khas untuk menyiram, memetik hasil buah malah menanam benih pokok. Penggunaan teknologi robotik di Malaysia dalam bidang pertanian masih dikatakan belum cukup meluas. Ini mungkin faktor modal merupakan punca utama. Seperti mana yang kita ketahui, pembinaan kos robot serta penyelenggaraannya mungkin memakan kos dan dianggapkan tidak kos efektif jika penggunaan teknologi tersebut dalam skala yang kecil. Maka untuk projek ini, skop yang hanya difokuskan adalah untuk membina sebuah robot yang boleh menyiram pokok serta mengenalpasti pokok mana yang perlu disiram dengan menggunaankan kuantiti yang tertentu. Penyiram air hanyalah pada pokok yang diletakkan dalam pasu.

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CHAPTER 1

PROJECT INTRODUCTION

1.0 Introduction

Nowadays robot has been widely used in various fields like industries, academic, research and development, agriculture and others. This chapter defines the robot, the project on a watering plant robot. The main objective of this project is to build an autonomous watering plant robot that has the capability to move using line following, detect different pots using IR sensor and water plants that are in pots according to a certain amount of water.This is where WaterBot is created for the purpose of this project. WaterBot is a short form for plant watering robot

1.1 Robots

The word robot can refer to both physical robots and virtual software agents, but the latter are usually referred to as bots. There is no consensus on which machines qualify as robots, but there is general agreement among experts and the public that robots tend to do some or all of the following: move around, operate a mechanical limb, sense and manipulate their environment, and exhibit intelligent behavior, especially behavior which mimics humans or other animals.

Stories of artificial helpers and companions and attempts to create them have a long history but fully autonomous machines only appeared in the 20th century. The first digitally operated and programmable robot, the Unimate, was installed in 1961 to lift hot pieces of metal from a die casting machine and stack them. Today, commercial and industrial robots are in widespread use performing jobs more cheaply or with greater accuracy and reliability than humans. They are also employed for jobs which are too dirty, dangerous or dull to be suitable for humans. Robots are widely used in manufacturing, assembly and packing, transport, earth and space exploration, surgery, weaponry, laboratory research, and mass production of consumer and industrial goods.

It is difficult to compare numbers of robots in different countries, since there are different definitions of what a "robot" is. The International Organization for Standardization gives a definition of robot in ISO 8373: "an automatically controlled, reprogrammable, multipurpose, manipulator programmable in three or more axes, which may be either fixed in place or mobile for use in industrial automation applications." This definition is used by the International Federation of Robotics, the European Robotics Research Network (EURON), and many national standards committees.

The Robotics Institute of America (RIA) uses a broader definition: a robot is a "re-programmable multi-functional manipulator designed to move materials, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks." The RIA subdivides robots into four classes: devices that manipulate objects with manual control, automated devices that manipulate objects with predetermined cycles, programmable and servo-controlled robots with continuous point-to-point trajectories, and robots of this last type which also acquire information from the environment and move intelligently in response.

1.2 Line Following Robot

Some of the earliest Automated Guided Vehicles (AGVs) were line following mobile robots. They might follow a visual line painted or embedded in the floor or ceiling or an electrical wire in the floor. Most of these robots operated a simple "keep the line in the center sensor" algorithm. They could not circumnavigate obstacles; they just stopped and waited when something blocked their path.

1.3 Problem Statement

Previously it was stated that humans are busy with their workload until they forget their obligations towards nature. Plants that are not watered for some time then die. To prevent this from to happening, a robot is designed and fabricated so that it can move using line following and then water plants that are in pots.

1.4 Objective

There are three objectives in this project. The first objective is to build a robot that is autonomous by using line following algorithm to navigate in the workplace.

The second objective is to build the IR sensor that can be used to differentiate between each pot. It will be used different patterns that will be attached to each pot. These patterns are design with using dots for its patterns. One IR sensor will detect one dot. If there are two pots that need to be watered, so there must be one dot to be used. It will use the formula number of pot = 2^N. N is the number of dots needed.

The last objective is to build a robot that will water plants in pots. For this project it will only focus on how to water the plants in pots but not how it waters the plants. This means, the mechanism of watering the plants only uses gravity method without any specific design of mechanism.

1.5 The scope of study

The following are the guidelines followed to ensure the project is conducted within its boundary of mechanical hardware modification, electronics including sensors and programming. This is to ensure the project is heading in the right direction to achieve its intended objectives.

The first scope is the mechanism part. The concept used to build the WaterBot is a mobile autonomous robot. There will be two motor to be used as actuators to move the robot. Power window motor will be used for this purpose. Then there will be a castor wheel in front of these two motors. The use of castor wheel is to minimise the cost to build the WaterBot. The shape of the robot will be build in circle shape so that the WaterBot will look more artistic.

Second scope is the electrical part. This involves the design of PIC microcontroller circuit for the robot brain, the controller for the pump, the motor driver for the power window motors, the IR comparator circuit for the line following purpose. Meanwhile for the identity detection to differentiate each pot, an IR module sensor will be bought and use for the WaterBot.

Last scope is the programming part. This part is very important for the WaterBot because it will act as its brain. The software will also determine the quantity of water to be pour for each pot only by using the concept of relay. In certain period of time, certain quantity of water will be poured. The line following will also be done in the software part to navigate its way of movement

1.6 Project Outline

This thesis consists of five chapters. Chapter one explains the introductory of the project including the objective and scope of this project. Also mention the problem statement and general project proposed.

Chapter two describes literature review more about previous study on topics that related to the project. It will cover both, universities research and implementations by other companies or organizations that suitable to relate on autonomous spy robot.

Chapter three will cover the methodology of the project. The main to topic of this chapter will describe the three most important subjects and there are hardware designing, electronic and circuit designing and programming using suitable microcontroller software.

Chapter four illustrates the result and discussion on the project after the project complete and finally chapter five will summarized the project in all field.

1.7 Summary

Robots are used in modern life to make our life more comfortable and easier for us to live in.WaterBot is the robot that has the ability to water plants that are in pots and move autonomously using line following. This project main objective is to accomplish the process of watering plants in pots using a robot and not focussing on the way of watering the plants.

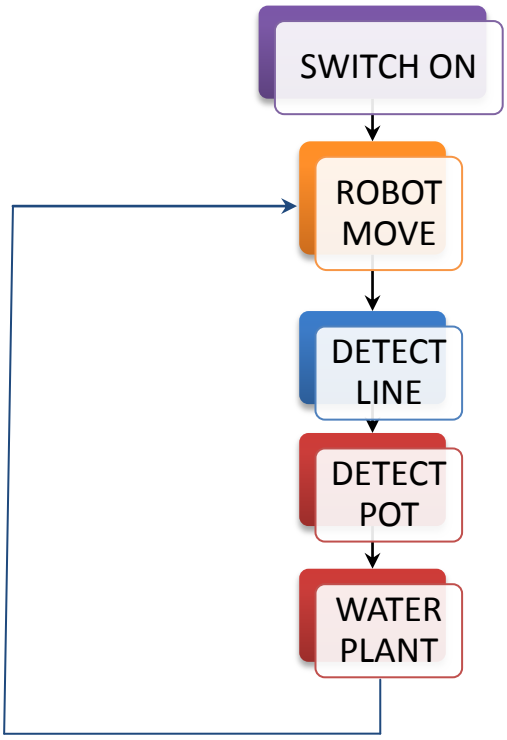

Figure 1.1: The Expected Outcome of the Project

CHAPTER 2

LITERATURE REVIEW

2.0 Literature Review

Literature review is vital to the research because from the previous researches, it can be guidelines to this project. In other words, it can bring a various idea and method to make this project a success. It also become a study case for this project to overcome with the new idea and different design compared to the previous project. Otherwise, from the literature review references it can develop the contents to this research. Below is a few listing that been done from the previous project.

This chapter focuses on the related fields and knowledge pertaining to the accomplishment of the thesis itself. Reading includes such as reference books, papers, websites, conferences articles and any documentation concerning the related applications and research works.

2.1 Watering Robot

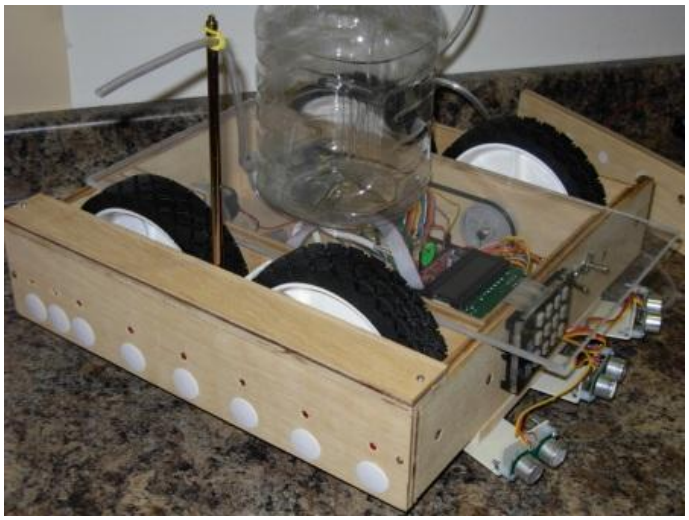

Figure 2.1: Picture of Watering Robot

Watering Robot, the plant-watering robot, will take over the task of adequately watering each plant at pre-determined intervals. Watering Robot will find and water the plants that are scheduled for watering. It will navigate around common obstacles found at a normal home until it reaches a thirsty plant. Once confirming the plant is on the list of to-be-watered plants, the robot dispenses a certain amount of water into the plants pot. After watering one plant, it finds other thirsty plants, remembering which ones still need watering. After watering all the plants, the robot returns to its home base and waits until it is time to water plants again.

Watering Robot will follow a predetermined path that will bring it in close proximity to plants. Using its magnetic sensor array, it will detect the nearby plant, line up with the plant, water it, and continue on to the next plant. A unique number will be assigned to each plant. This number will be represented with a panel of magnets. The magnets will assist the robot in lining up with the plant and confirming each plants identity. A small database in the robots memory will contain the schedule and identity of the pots to be watered and if practical, the approximate amount to water each pot.

A small, electrical water pump (windshield wiper fluid pump) will deliver water from the on-robot reservoir to the pot. A tube will direct the water from the pump to inside the pot. Once the robot exhausts its water supply, it will return to its home base and wait refilling

2.2 Robots From Challenge 2006

Figure 2.2: Red the Robot

The aim was to build a robot capable of acquiring, transporting and watering a plant in our lobby. This fun exercise was designed to promote critical thinking, planning, designing, team work and ability to execute. The two teams were each given a robot kit as a basic tool but were allowed to order any other supplies needed. The robot had to carry at least 8 oz. of water but each additional ounce carried would score an extra point. One point would also be added for each ounce that the robot weighed less than 8 lbs. A totally autonomous robot, completing his task without human intervention or radio control, would have its score doubled. Red weight 2.25 lbs., carried one gallon of water, and had an ingenious design incorporating optical encoders around the wheels and bumper switches at the front.

Figure 2.3: Blue Robot

Both teams had working, autonomous robots. The Blue team's robot took a wrong turn and spilt its water, wetting the electronics. The Red team's robot performed flawlessly until the very end. Theirs was also the lighter of the two, and carried more water. Their ingenious design incorporated optical encoders and front bumpers. To ensure the robot went straight even if the motors powering each side were going at different speeds, optical encoders were used to compare the revolutions made by each motor and correct them so they were kept the same. To correct for any error still built up along the course, two bumper switches mounted on the front of the robot triggered upon contact with the bucket depending on whether the robot was facing the bucket or not. For instance, if only the left bumper switch was depressed then the robot knew it was too far to the right and corrected for this by backing up and turning left slightly, repeating until both bumper switches were triggered, indicating the robot was centered facing the bucket and ready to dispense its water.

2.3 Splatbot

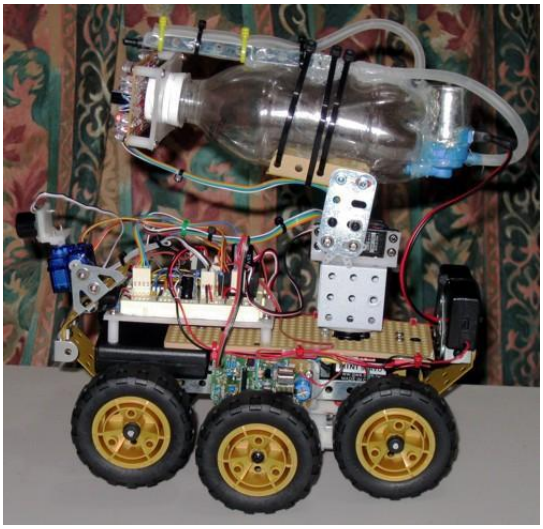

Figure 2.4: Design of Splatbot

Specifications of this robot:-

- Weight:600 grams
- Actuators / output devices: 2x Solarbotics GM3, 2x HXT900 servos, 2x GWS mini BB servos, 1x windscreen wiper water pump
- Control method: fully autonomous
- CPU: Picaxe 28x1
- Power source: 6xAA NiMH - 7.2V
- Programming language: picbasic
- Sensors / input devices: Maxbotix EZ1, homemade IR obstacle detectors
- Target environment: Outdoors, nocturnal, indoors

SplatBot has a meccano chassis and wheels. Two motors got from a toy dinosaur (similar to solarbotics GM3) are mounted in the center of the chassis with a polymorph bracket. These motors are driven by giant servo kits (visible behind the center wheel) that convert them to continuous rotation servos for easier speed/direction control.

Figure 2.5: Pump for Splatbot

The bottle is a 300mL soft drink bottle. This seems to be a good size for the robot. The pump is just a cheap windscreen wiper water pump from a local autoparts shop. This cost about $10 US. The tube above the meccano is a breather tube. The tube within the meccano struts is the output with a black plastic fish tank tube joiner on the end for a nozzle. This about doubles the distance to 2m or so. Remember that don’t want to hurt any animals with this so pressure is limitted and besides, the range of the object trackers is less than a meter so this is heaps for the purpose. It works quite well considering the pump is designed for 12-15V.

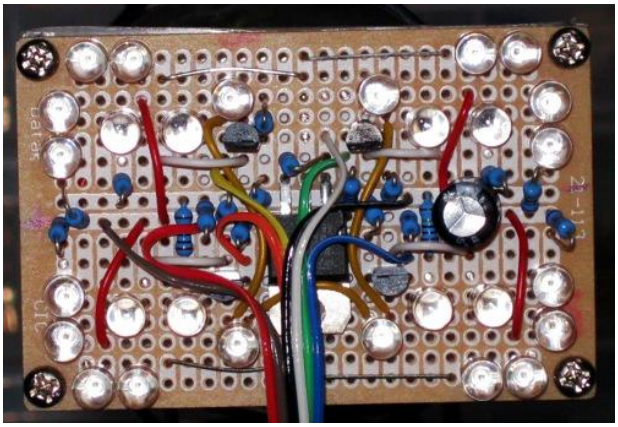

Figure 2.6: Sensor Array

This is the sensor array. Each of the four sensors consist of two phototransistors in parallel and 5xIR LEDs. There are 20 LEDs drawing 250mA in total. The IR LEDs are only on for a small percentage of the time so they don't have a significant effect on battery life. Hoped to get more range from the array but still don't get much more than 500mm at night.

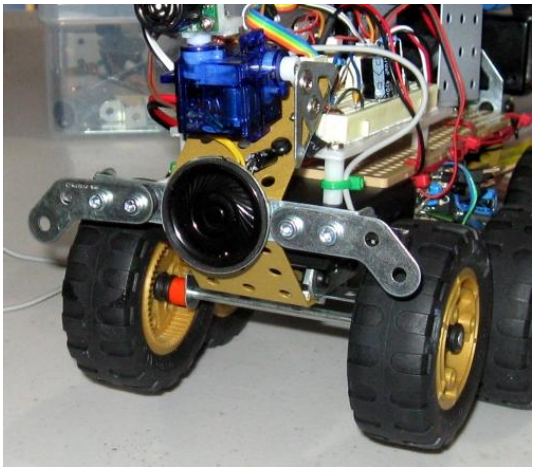

Figure 2.7: Front part of SplatBot

SplatBot would occasionally hit something with one of the front wheels and get caught without realising it. Now it has limit switches on the front bumper which are monitored by an interrupt routine. This allows him to react quickly to a collision. It also fitted a speaker so he can make various noises to indicate certain conditions. He now emits a two tone warning if he collides.

2.4 Summary

From the literature review discussed in this chapter, there were many projects that are related to WaterBot. So this makes this previous robot could become references to this project. However, the input and information given really helps in improving the robot development. Thus, with each of this project that have been stated, WaterBot will be designed as maybe pioneer to make agriculture field in Malaysia more advance in using robotics in its area.

CHAPTER 3

PROJECT METHODOLOGY

3.0 Methodology

A proper planning is needed to ensure this project is completed on time. The developing process of the WaterBot involves in design of the main controller circuit that includes the electronics and motorization, hardware,debugging and etc. Therefore, the following chapter discusses the methods and materials employed in the design and fabrication of the project, as well as its manner of operation. Basically, this project is an interdisciplinary field that ranges in scope from the design of mechanical, electrical components and software development.

3.1 Overall Flow of Project Activities

In the development of this project, the flow can be classified into input, process, output and feedback. Figure 3.1 shows the research methodology flow chart for completing this project

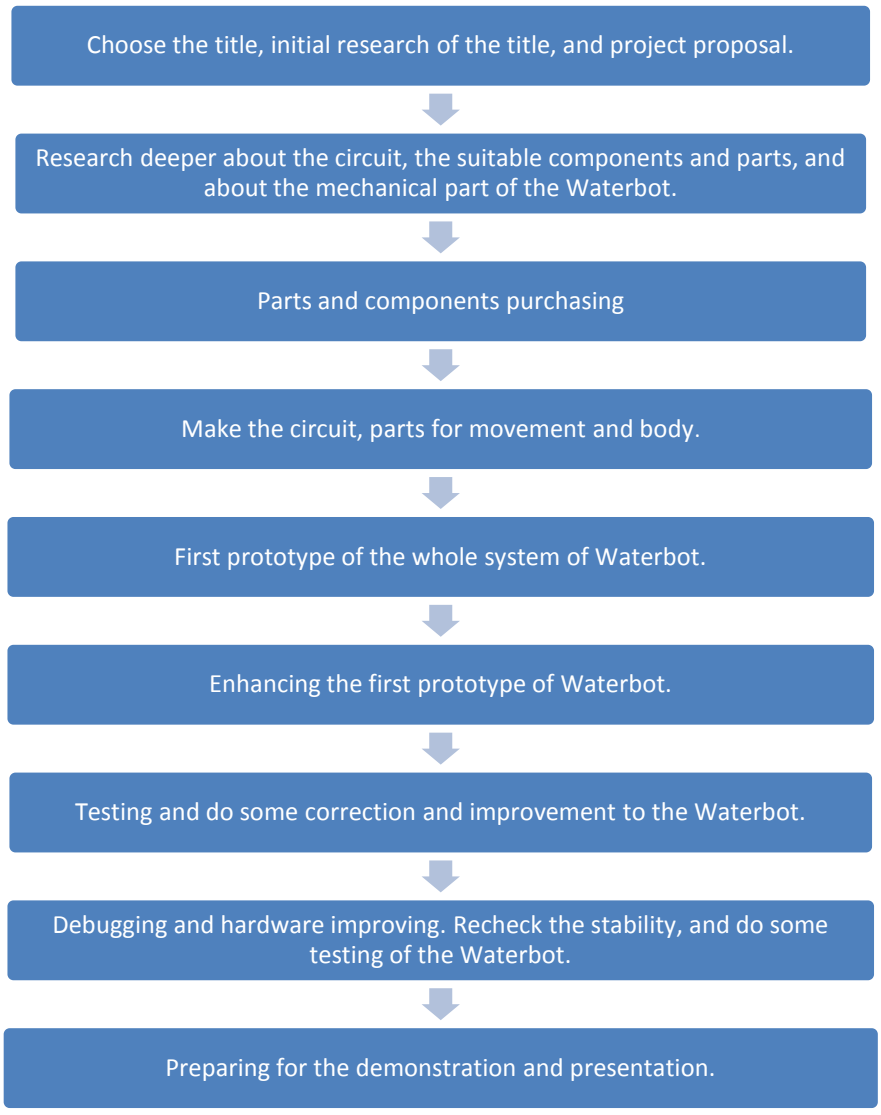
Choose the title, initial research of the title, and project proposal.
Research deeper about the circuit, the suitable components and parts, and about the mechanical part of the Waterbot.
Parts and components purchasing
Make the circuit, parts for movement and body.
First prototype of the whole system of Waterbot.
Enhancing the first prototype of Waterbot.
Testing and do some correction and improvement to the Waterbot.
Debugging and hardware improving. Recheck the stability, and do some testing of the Waterbot.
Preparing for the demonstration and presentation.

Figure 3.1: Methodology Flowchart

3.2 Mechanical Part

In the mechanical design there are two parts that had to be figured out properly. Firstly was the motor. The motor is the important and vital for the movement of the robot. The robot that will be design maybe heavy due to the amount of water carried to supply in the watering process. So a high torque motor will be used to overcome the weight problem that will be encountered during the fabrication of the robot. Disadvantages of previous project that had been research, most of the project was not very fast in speed. By improving this, a motor that has average speed will be implemented in the design. A power window motor is the suitable motor that will be use in this project. It also meets the specification of the project that has a high tork and moderate speed. The second important part is the pump for watering plants. After doing some research and findings, a DC water pump will be chosen to be implemented for this design. This is because using a DC water pump is easier to control than using an AC water pump.

3.2.1 Mechanical Design

There is software that can have capability to people design their mechanical drawing like Google Sketchup, Auto CAD, and others. By using these software, people will able to illustrate their design in three dimension form and capable to adapt the design to the real component. Others this software will give advantage for mechanical maker to choose the suitable component to apply it at suitable position.

For this project uses Google Sketchup to design the mechanical struture of the robot because the software is easier to be use than other drawing softwares. Google SketchUp is a 3D modeling program designed for architects, civil engineers, filmmakers, game developers, and related professions. It also includes features to

facilitate the placement of models in Google Earth. It was designed to be easier to use than other three dimension CAD (computer aided design) programs.

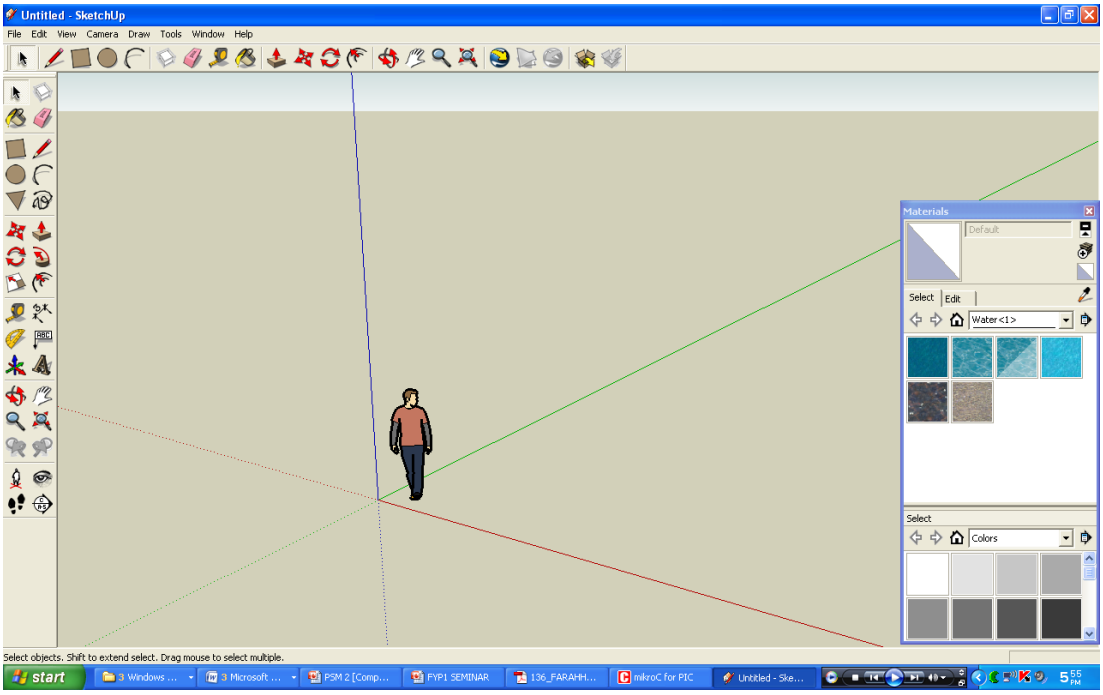

Figure 3.2: The front page of Google Sketchup Software.

Figure 3.2 show the main window of Google Skechup before the mechanical drawing design precede. In this main window the usable tool icon will display with differences function to make the user easy to start the design.

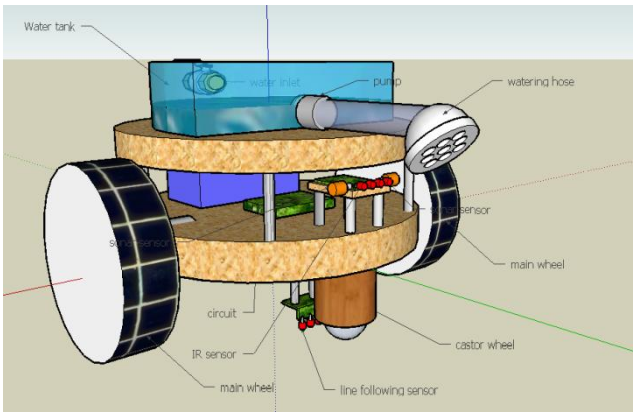

Figure 3.3: Mechanical Design of the WaterBot Using Google Sketchup

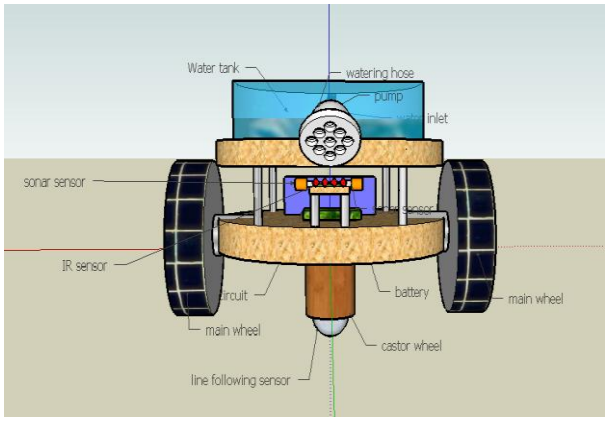

Figure 3.4: Front View

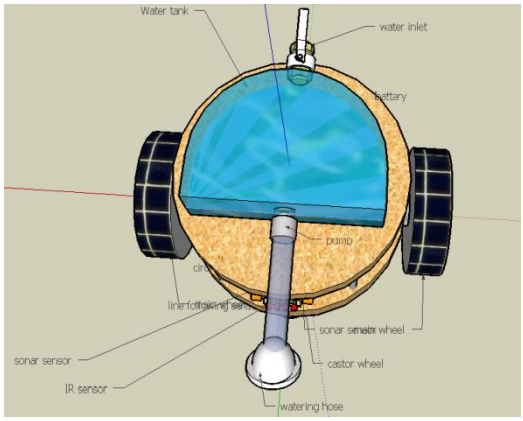

Figure 3.5: Top View

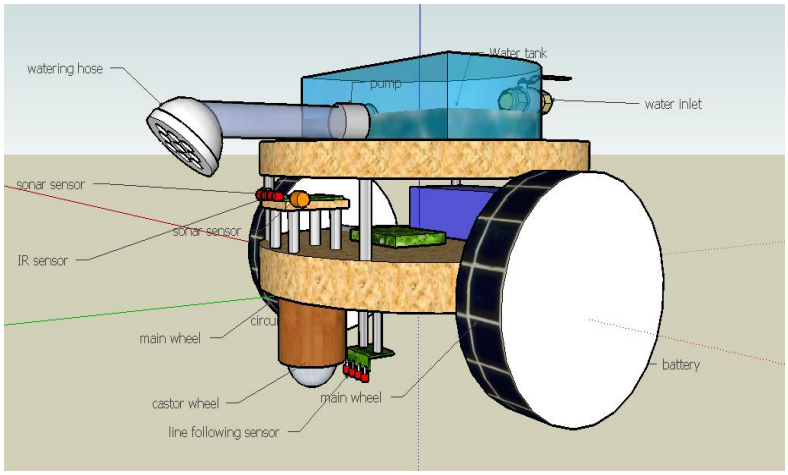

Figure 3.6: Side View

Figure 3.3 shows the overall mechanical design of the WaterBot where the mechanical component connection and board location are shown. All component location has been specific to make sure the robot follow the project objective where the location of IR sensor for the line following ts placed behind of the castor wheel to make sure the robot able to detect the path for the line following process.

Figure 3.4, Figure 3.5 and Figure 3.6 shows the WaterBot designs from front view, top view and side view. The water tank is put at the center of the robot so that it can give balance to the robot due to its heavy weight. Meanwhile the battery is put at the back of the lower part of the robot so it can also gives balance to the robot due to the weight of the water tank. All the circuits are place at the lower part of the robot

to make sure that it will be protected the pipe. The pot sensor is place a bit lower than the pipe because that is the suitable area to detect the patterns that will be stamp at each pot.

3.2.2 Power Window Motor

This project will use two DC power window motors that are use for the wheel movement. The first motor is position at the right side of the robot and the other one is position at the left side of the robot.

Figure 3.7: DC Power Window Motor

The DC power window motor is used to move the wheel to any direction. The mechanism of the motor will act differently to the corresponding IR sensors that detect the path of the line following. When none of the IR sensors detect the path, this means that the robot is out of track, so it will start the search mode to find the path so that it can be on track again. The speed of motor will be controlled by using PWM (Pulse Width Modulator).

3.2.3 Water Pump

As stated in the previous chapters, the water pump that will be used for the watering process is a DC water pump. This water pump was hard to find and it was bought in Singapore. The water pump is control by a 12V SRD relay that was specially design for the watering purpose. The amount of water that will be watered is depends on the delay that is use to switch on the water pump. The delay is set in the programming. The longer the delay, the more water will be pumped to the plants.

Figure 3.8: DC Water Pump

3.3 Electronic and Circuit Part

For the robot able to function properly, the electronic part must be perfectly installed to the robot. In this project there are several circuits that need to be design for the robot. First circuit is the main circuit that consist voltage regulator circuit to give the voltage to turn on the integrated circuit (IC) and to avoid the circuit burn. Second is the IR sensors that are use to detect the line. Next is the power window motor controller that acts as a driver to the motor in this robot.

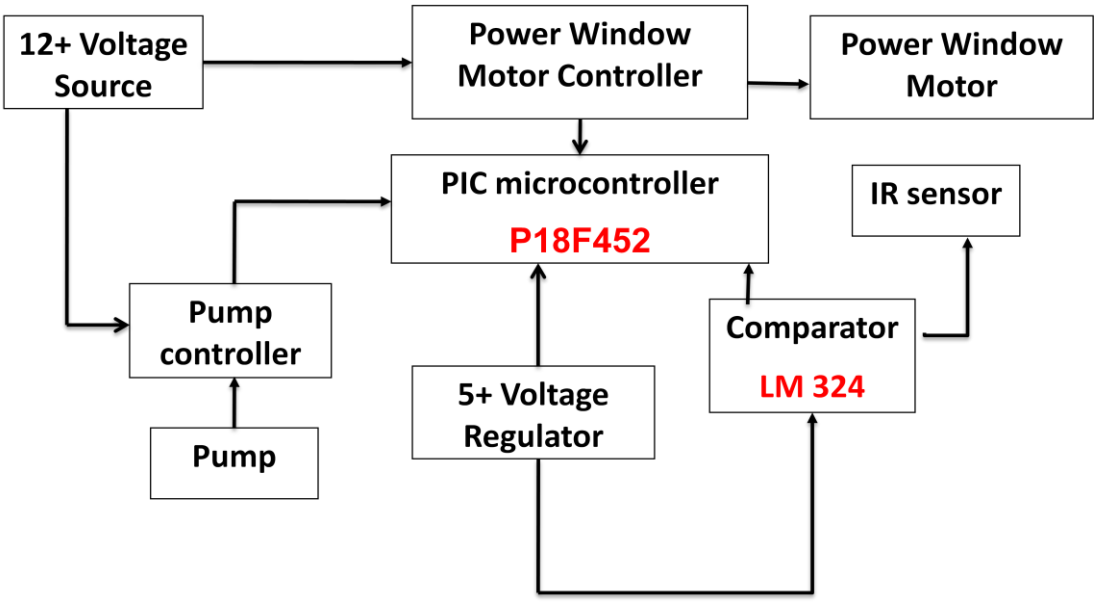

Figure 3.9: The Circuit Attachment**.**

Figure 3.9 show the circuit attach to the WaterBot. All circuit will be attach to the main board The main board consist voltage regulator and microcontroller PIC18F452..

3.3.1 Electronic Design

On the circuit and electronics parts, the first stage of the design is to understand the requirements of the project and the limitation of various constraints such as the level of technology, microcontroller reliability and the complexity of programming and interfacing. First, intensive studies was conducted to learn and observe the others circuit and devices used by previous year projects and research projects conducted worldwide. From those technical studies of the circuit, schematic layout and components used was recorded of the suitable and most reliable circuits. From there, components and peripheral interfacing method are modified and applied at the electronics stage.

3.3.2 PIC Microcontroller and Voltage Regulator

In this project, PIC18F452 Microcontroller will serve as the brain of the WaterBot and controls all actions where it was placed on the main controller circuit. The microcontroller is chosen because it provides more input and output ports, large size of program storage and more peripherals supported. The basic operation is like the input signals are sent to the microcontroller and the microcontroller will send instructions to control the WaterBot.

Microchip PIC18F452 Microcontroller that was chosen comes in 40 pins package (PDIP) .Microcontroller PIC18F452 runs at 40MHz with 100ns instruction time. Speaking of instruction, the space or size of PIC18F452 has space of 16k lines for Assembly Code. Figure 3.10 shows the pin diagram of PIC18F452 and Table 3.1 shows the device features for PIC18F452.

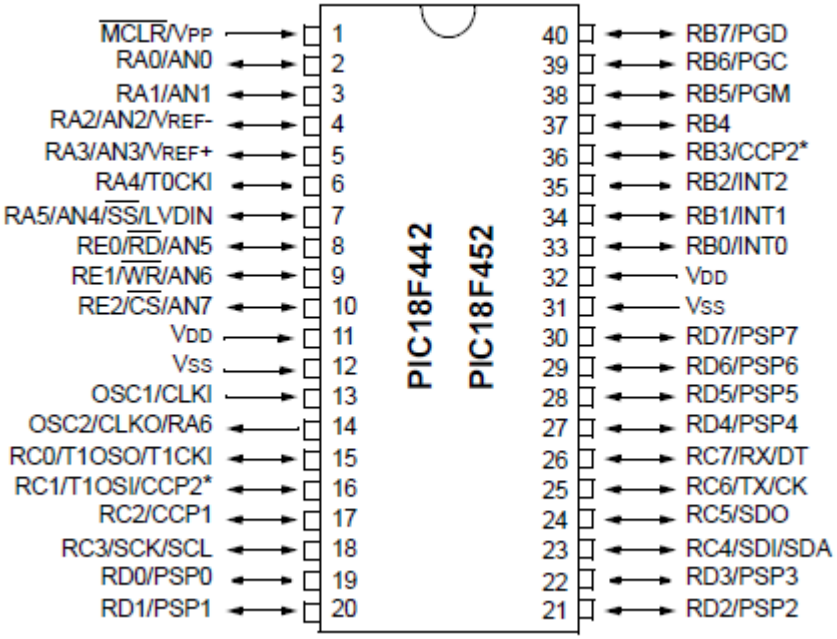

Figure 3.10: Pin Diagram for PIC18F452 Microcontroller

Table 3.1 Device Features of PIC Microcontroller

Device Features	PIC18F452
Operating Frequency	DC – 40 MHz
Program Memory (Bytes)	32K
Program Memory (Instructions)	16384
Data Memory (Bytes)	1536
Data EEPROM Memory (Bytes)	256
Interrupt Sources	18
I/O Ports	Ports A, B, C, D, E
Timers	4
Capture/Compare/PWM Modules	2
Serial Communications	MSSP, Addressable USART
Parallel Communications	PSP
10-bit Analog-to-Digital Module	8 input channels
RESETS (and Delays)	POR, BOR, RESET Instruction, Stack Full, Stack Underflow (PWRT, OST)
Programmable Low Voltage Detect	Yes
Programmable Brown-out Reset	Yes
Instruction Set	75 Instructions

PIC Microcontroller required basic circuit to operate. They are Power Supply which it need the 5V and Ground (GND), Crystal or Oscillator for the clock (time) in order for microcontroller to execute instruction, Reset for restart the microcontroller and I/O support circuit for microcontroller to read inputs and control the output.

For this project, the voltage range of power source could be given for this circuit board is between 7V and 15V. Higher input voltage will produce more heat at LM7805 voltage regulator. Typical voltage is 9V. Anyhow, LM7805 will still generate some heat at 9V. LM7805 (1A maximum) will regulate the given voltage to 5V (Vcc) for supplying power to the PIC Microcontroller and pull-up the push button (input). The purpose of using diode (D1) is for circuit protection in case the polarity of the power source is incorrect. Capacitors are use to stabilize the voltage input and output of the LM7805. D2 is a green LED (small) as power indicator.

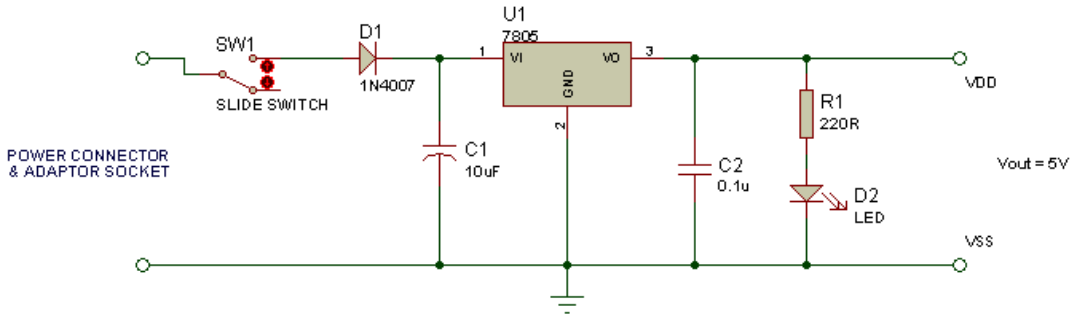

Figure 3.11: Schematic Diagram for Voltage Regulator Circuit

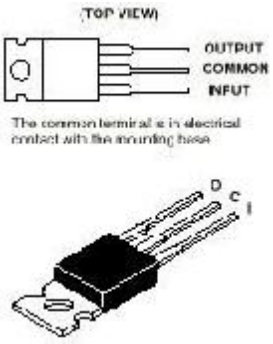

Figure 3.12: Voltage Regulator

Two voltage regulator will be design for this robot because to prevent current drop between the PIC Microcontroller circuit and the IR sensor circuit. The circuit is shown in Figure 3.13.

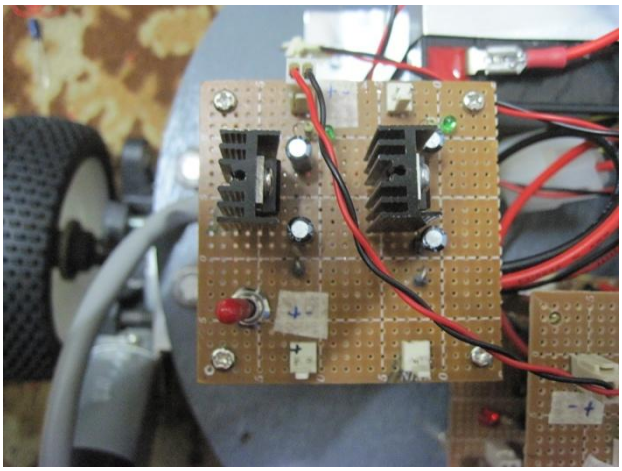

Figure 3.13: Voltage Regulator of WaterBot

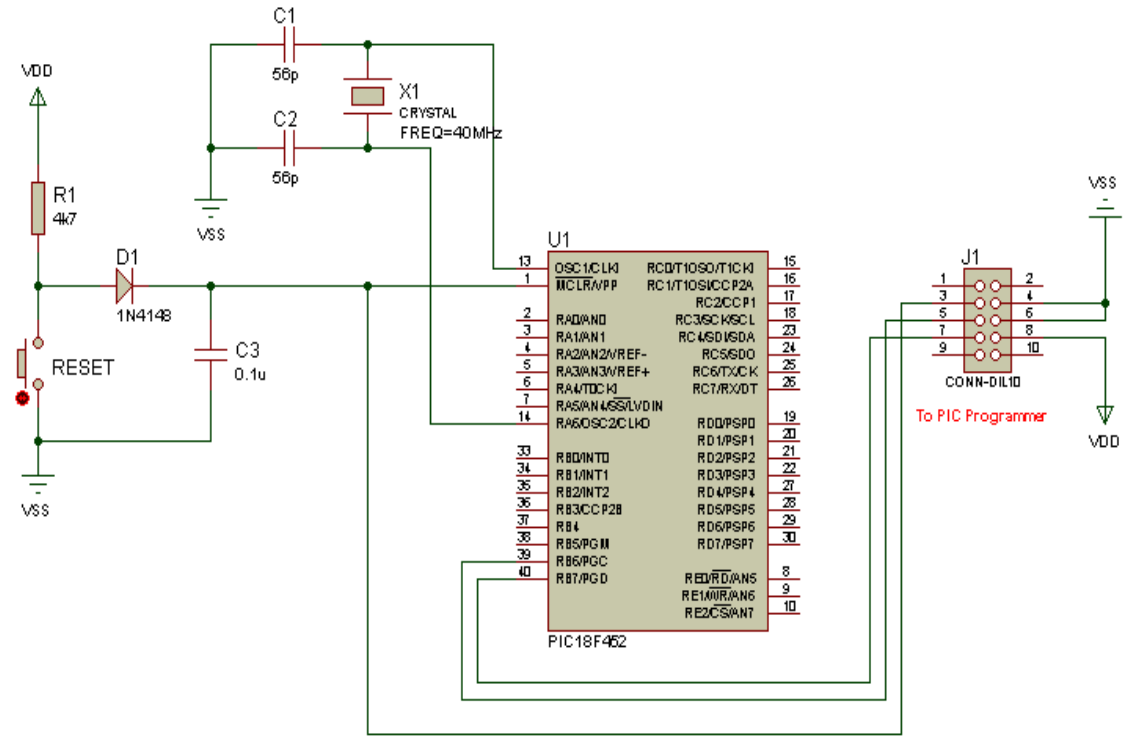

Figure 3.14: Schematic Diagram of Basic Circuit for Microcontroller

PIC Microcontroller also require a clock to work where it provide signal clock to PIC Microcontroller and normally crystals, clock oscillators or RC circuit been apply. In this project, 20MHz crystal was used for PIC18F452 and two 56pF capacitors which are parallel connected to filter out external noise from interfering with the crystal frequency. Some PICs have a build in 8MHz RC clock and it requires no external components.

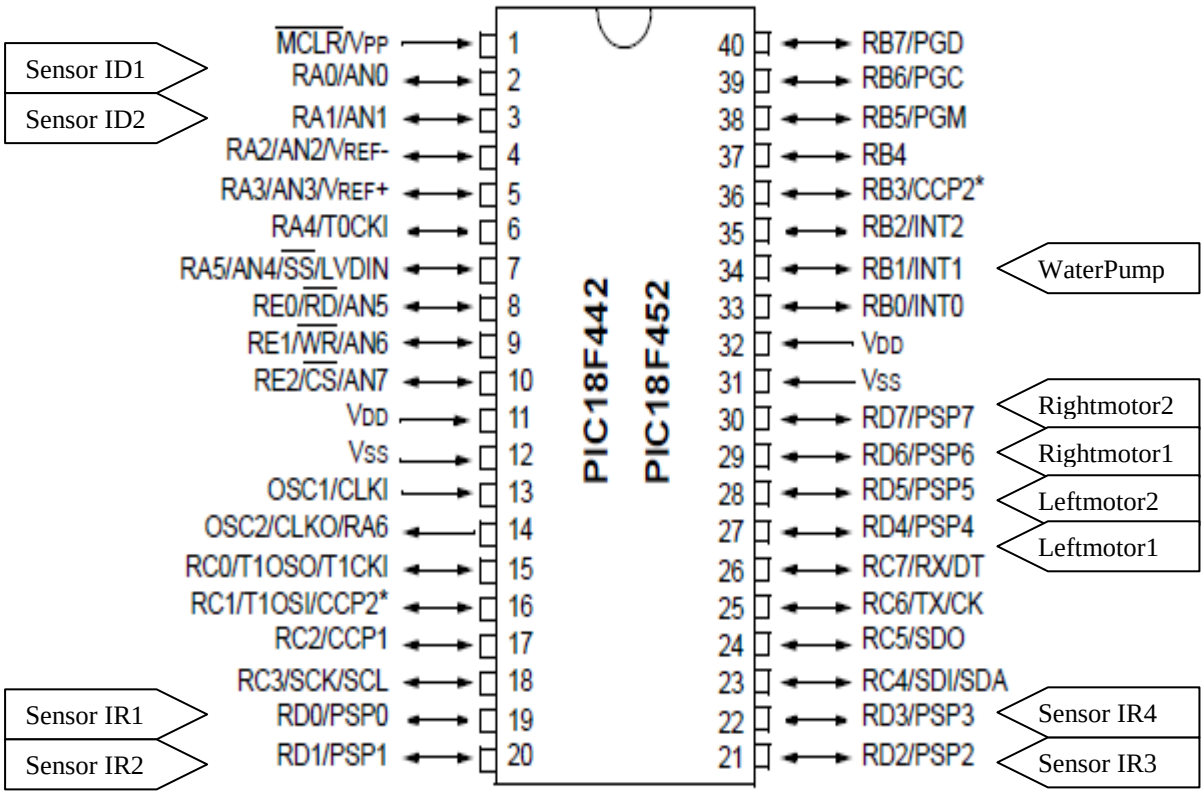

Figure 3.15: The Usage of PIC18F452 Port

Microcontroller utilized to be the brain of the WaterBot and it is programmed to execute an outputs for two DC motors when receive signals from the IR sensors that is connected at pin RD0, RD1, RD2 and RD3. PortD pins (RD4, RD5, RD6 and RD7) were assigned for power window motor controller output. Beside that, the analog inputs from sensors as the line detection for the line following program. The microcontroller processes the inputs and instructs the motors simultaneously to control the WaterBot. Figure 3.15 shows microcontroller I/O port that been used and Figure 3.16 shows the microcontroller I/O circuit.

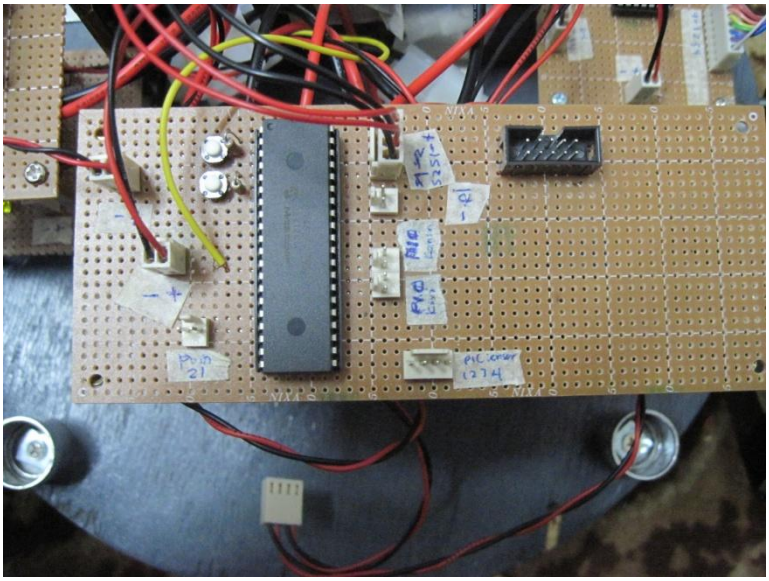

Figure 3.16: Microcontroller I/O Circuit

3.3.3 IR Sensor

Infra-Red (IR) is the light source used as a sensor in this project to sense the line following. The implement of sensor is when the user set the operation mode to autonomous. Detection signal from sensors will generate as input to PIC Microcontroller. Microcontroller will execute the movement instruction of the WaterBot. These IR sensor are needed to build an autonomous robot that able to move itself without need any external aid from human. Figure 3.17 below shows the schematic diagram of designed IR sensor circuit.

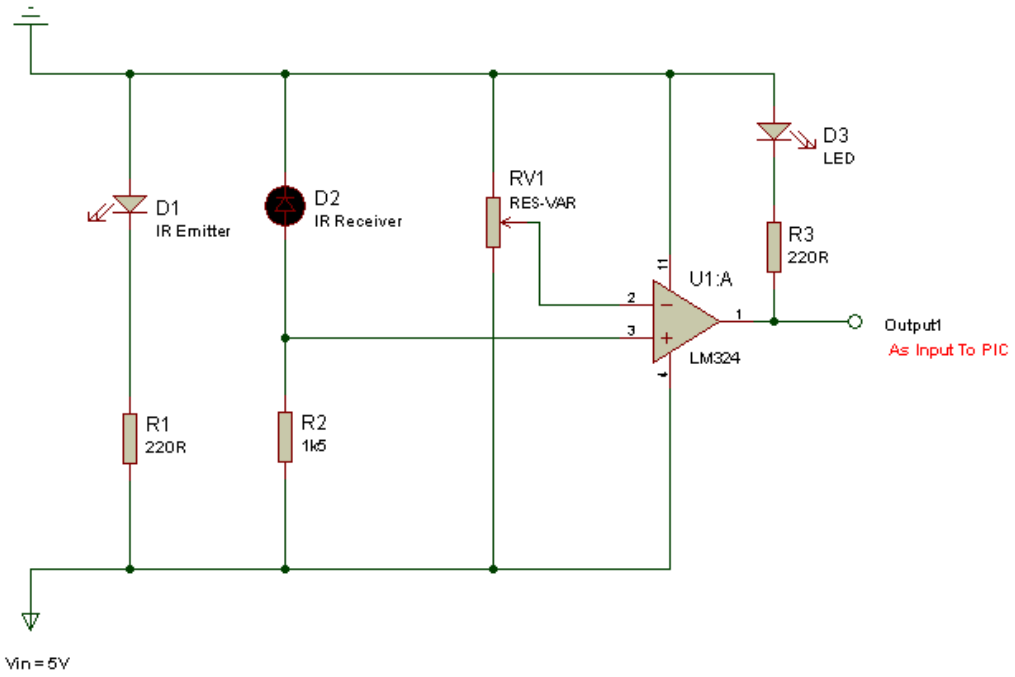

Figure 3.17: Schematic Diagram of IR Sensor Circuit

When the IR receiver receives infrared; it will generate voltage at its pin. The generated voltage is in the range from 0V to 5V depends on the intensity of infrared it received. The voltage will drop to zero if there is no infrared received. Error will occur when the microcontroller is unable to recognize value other than 0V and 5V. This is due to, if the infrared reflected is less, the receiver would probably produce a 2V or 3V and microcontroller is unable to deal with these analog values.

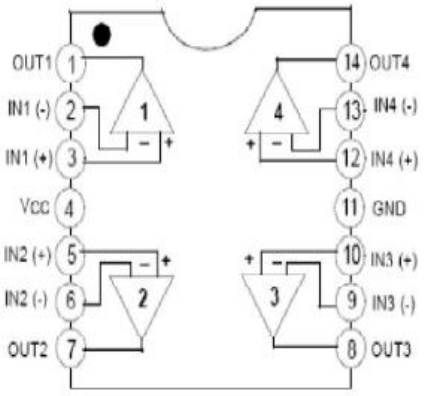

Figure 3.18: Schematic Diagram of LM324

Thus, a comparator of LM324 is needed to solve this error. By using this LM324, the output voltage from IR receiver will be compared with an input voltage through a variable resistor, and the corresponding digital output will be feed to the microcontroller. Figure 3.18 above shows the schematic diagram of LM324 where there are four comparators built in the chip.

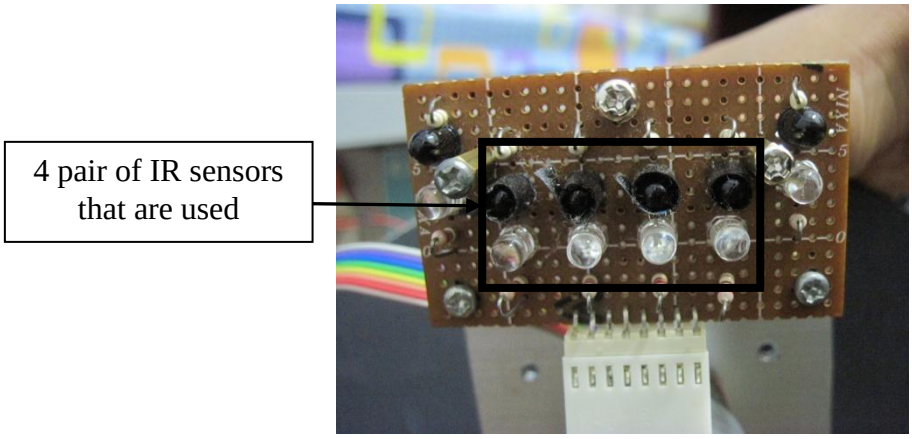

Figure 3.19: Four pairs of IR sensors

As indicated before, four pairs of IR sensors are used to be the eyes for the WaterBot to detect the line following. Where these four pairs integrated with relevant circuit is used for sensor1, sensor2, sensor3 and sensor 4 to detect the line following. The output from LM324 is connected to PIC18F452 where these pins where initialized as following, port RD0 for sensor1, RD1 for sensor2, RD2 for sensor3 and RD4 for sensor 4 input. Figure 3.20 shown below the arrangement of IR sensors, LM324, preset 10kΩ and the indicator on the circuit board.

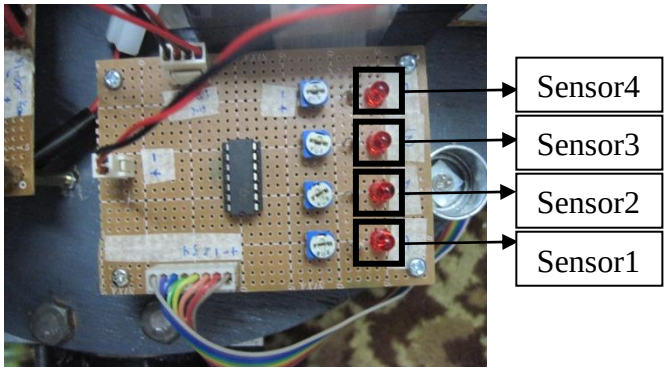

Figure 3.20: IR Sensor Circuit

3.3.4 ID pot dectection

The ID pot dectection is using an basic IR sensor. Infra-red (IR) sensor use the concept of reflection of light to function. It consists of two devices, which called as receiver (Rx) and transmitter (Tx). Transmitter transmits the IR packet to an object while receiver receives the packet sent after the light reflected from the object.

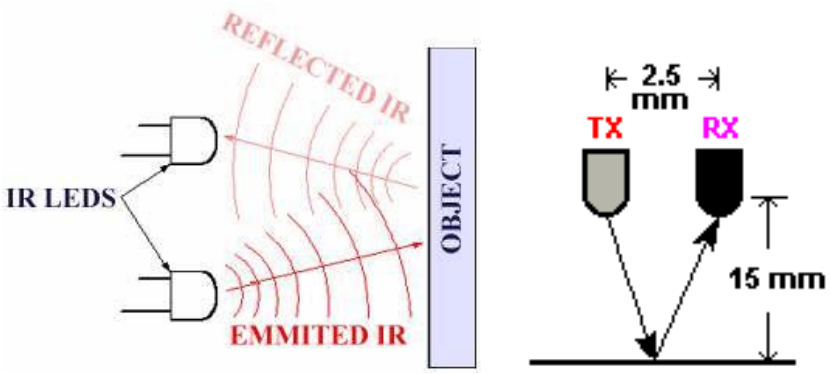

Figure 3.21: IR Sensor Arrangement and Operation

Figure 3.21 the position of both transmitter and receiver diode and the way of the IR sensor operate. From the figure detection or reflected packets ranges up to 15 mm from the object. However, the ranges of transmit and receive depend on type of diode used. Many manufacturers now provide a wide range of IR diodes for batter performance. In normal condition where no packets receive, the pin goes high (logic 1) but, after receiving IR packet, the pins grounded (logic 0). This concept represents the digital logic and easily adapted for this project. IR sensors used as obstacle detection sensors. It gives ability to the robot to avoid any potential collision.

As stated in early section, an IR sensor module will be used for this purpose. This Medium Range Infrared sensor offers simple, user friendly and fast obstacle detection using infrared; it is non contact detection. The implementations of modulated IR signal immune the sensor to the interferences caused by the normal light of a light bulb or the sun light. The sensing distance can be adjusted manually.

The product features include:

• **5V powered**, low current consumption, **less than 10mA**.
• 3 pin interface which are **signal**, **GND** and **5V**.
• Small **LED as indicator** for detection status.
• Obstacle detection up to **10cm**.
• **Adjustable sensing range** (2cm – 10cm).
• Small size makes it easy to assembly.
• Single bit output.
• Compatible with all types of microcontrollers.
• **Dimension:** 2.6cm x 2cm

The sensor uses special sensor to modulate IR signal emitted from 2 IR transmitters and detects the modulated IR signal reflected back from a nearby object. This sensor has a built-in IR LED driver to modulate the IR signal at 38 KHz to match the built-in detector. The modulated IR signal immunes the sensor from the interferences caused by the normal light of a light bulb or the sun light. The module will output a HIGH if no object is detected and a LOW if an object is detected.

Pin	Name	Function
+	VCC	Connects to Vcc (+4V to + 6V)
-	Ground	Connects to Ground
s	Output signal	Connects to an I/O pin of microcontroller which set to INPUT mode (or transistor/MOSFET).

Absolute Maximum Rating

Parameter	Min	Max	Unit
Operating voltage	4	6	V
Sensing range	2	10	cm

Table 3.2: Pin Definition of IR01A IR Sensor and Ratings

The Medium Range Infrared Sensor has a sensing range of approximately 2cm to 10cm. The sensitivity can vary with the reflectivity of the object and the ambient lighting. The modulated IR signal will reflect more on white surface and reflect less on black surface. The sensor is designed to adjustable sensing range. User may adjust sensing range by using the preset on IR01A for different application.

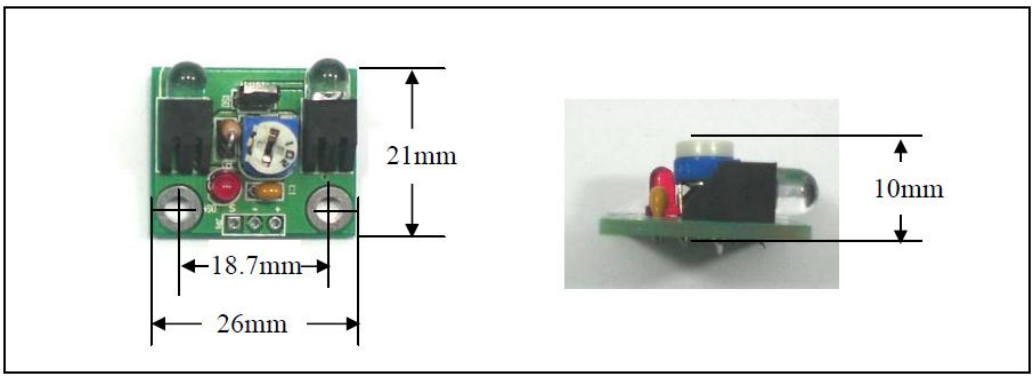

Figure 3.22: Product Dimension

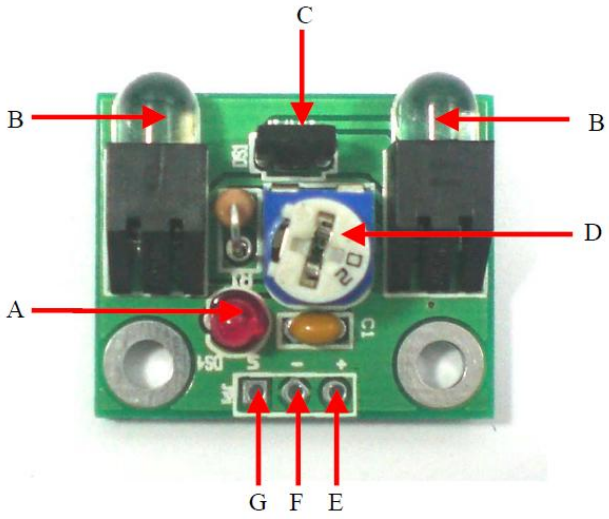

Figure 3.23: Product Layout

Label	Function	Label	Function
A	Signal indicator LED	**E**	The hole to solder and connect VCC (+).
B	IR transmitter	**F**	The hole to solder and connect GND (-)
C	IR sensor	**G**	The hole to solder and connect output signal (s)
D	Preset		

Table 3.3: Product details

A – is a signal indicators LED for IR01A. The LED will turn ON when signal is detected on IR01A.

B – are 2 IR transmitters, the output IR signal is modulated at 38Khz.

C – is IR sensor. This sensor modulates IR signal emitted from 2 IR transmitters and detects the modulated IR signal reflected back from a nearby object.

D – is a 1K Ohm preset for user to adjust the sensing range. The sensing range is 2cm –10cm. (Performance of the sensor will vary with the reflectivity of the object and the ambient lighting.)

E – is a hole to solder and connect the power supply to IR01A. User may supply 4V-6V to IR01A, the typical voltage is 5V.

F – is a hole to solder and connect Ground to IR01A. User may connect the GND(-) of IR01A to the Ground (0V) of the control board.

G – is a hole to solder and connect the output signal from IR01A. User may connect the signal pin(s) from IR01A to an I/O pin of microcontroller which set to INPUT mode. The output signal of IR01A is LOW or 0V when an object detected.

3.3.5 Power Window Motor Controller

Power window motor controller is the device that use to control DC power window motor speed by using PWM (Pulse Width Modulator) and to control the DC power window motor direction. In this project the power window motor driver use is design and fabricate specially for the robot because the power window motor couldn't use ordinary motor driver such as L293D due to its limited source of voltage supply.

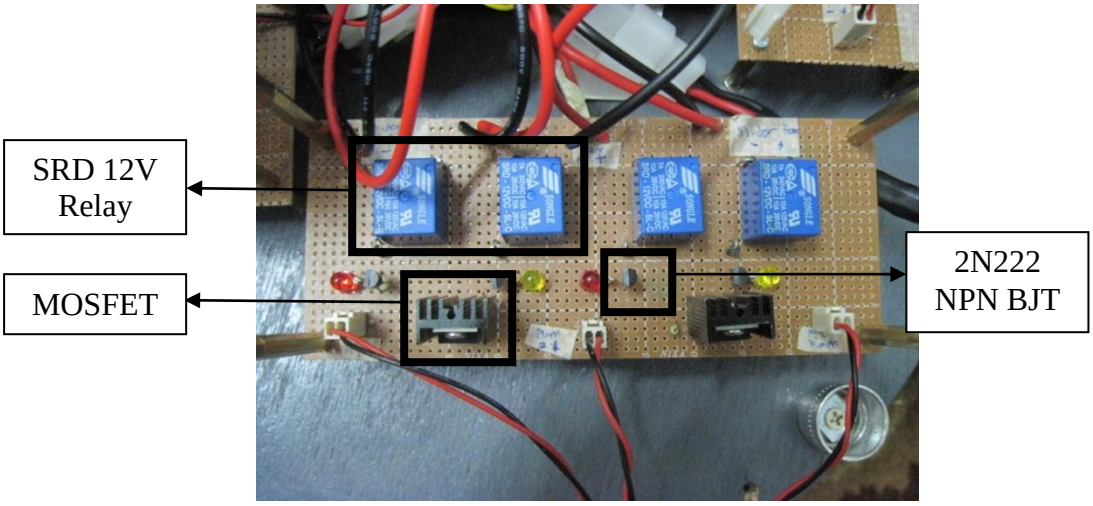

Figure 3.24: Power Window Motor Controller

From the Figure 3.24, the contoller has four 12 SRD relays where two relays will control one power window motor. These relays are responsible to control the direction of the motor. The use of a MOSFET for the PWM control of each one will be connected to Pin CCP1 and CCP2 at PIC microcontroller Meanwhile the NPN BJT 2N222 is use as switch to control the relay with the PIC Microcontroller

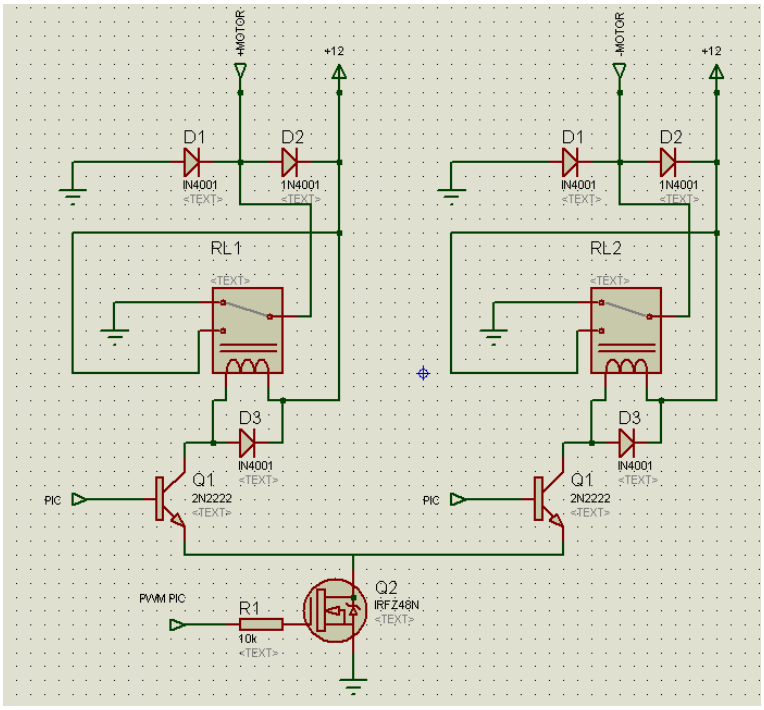

Figure 3.25: Schematic circuit for one power window motor

3.3.6 Pump Controller

The pump controller uses one SRD 5V relay to act as a switch betwween the PIC Microcontroller and the water pump. The circuit is consists a 2N222 BJT 12V and 5V voltage source and a LED diod as a indicator that the pump is ON. Figure 3.26 shows the board and Figure 3.27 shows its schematic.

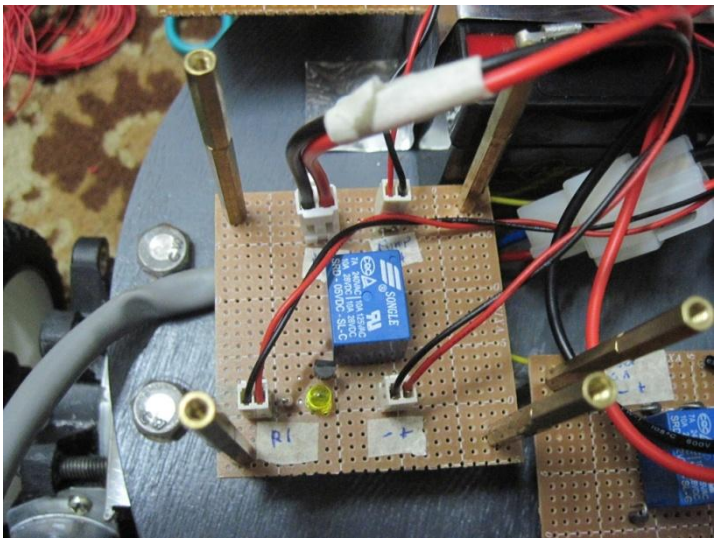

Figure 3.26: Pump controller

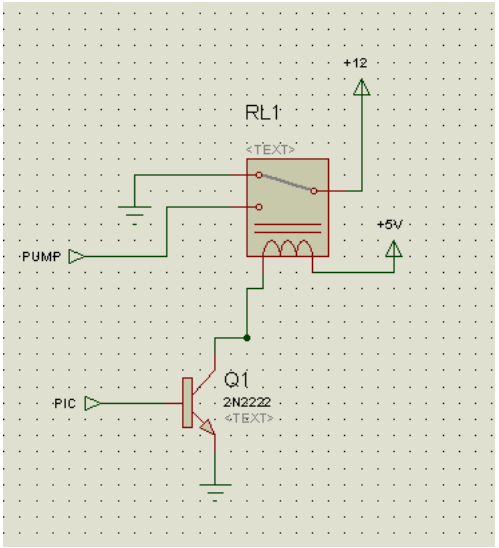

Figure 3.27: Schematic Circuit for Pump Controller

3.4 Programming Part

3.4.1 Micro C programming

Programming part is the final state in completing robot project where the programming is the mind of the robot to it makes decision when it faced some situation. The programming is build by user to make sure the robot follow all the instruction and the all sensor able to use when the programming insert. All program written will be burnt into PIC microcontroller because the PIC as the brain from robot and the programming as its mind. Without programming the robot will not able to move and all sensors will not function because the data send by sensor not able to process and execute.

3.4.2 Micro C programming

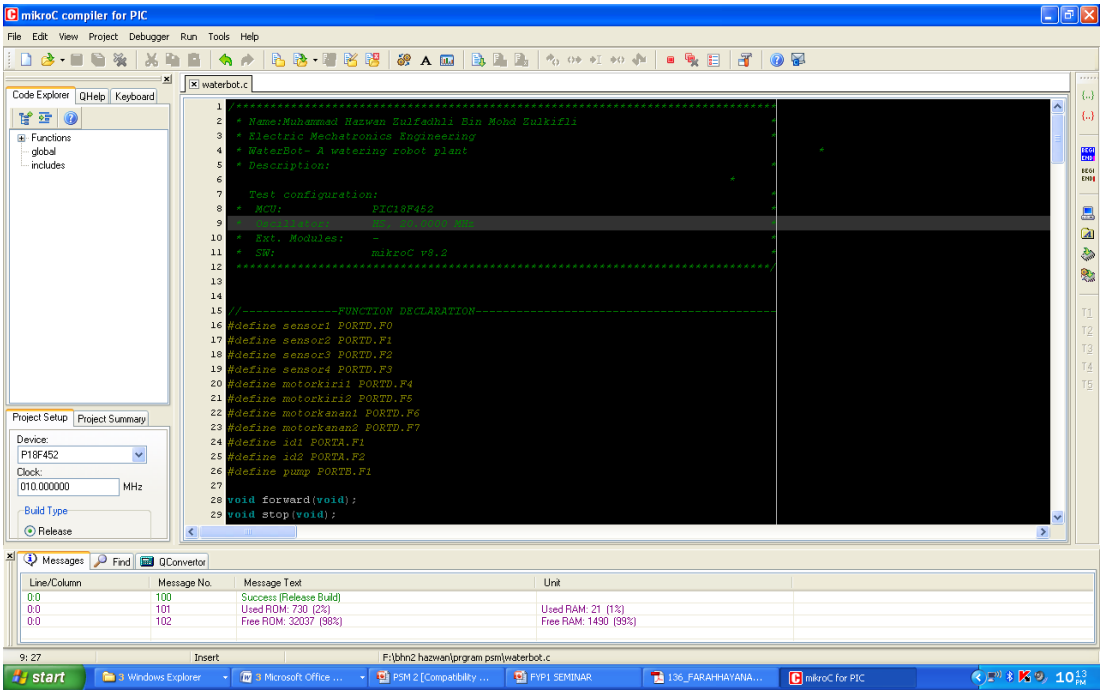

Figure 3.28: Micro C Front Window

Figure 3.28 shows the main window of Micro C programming where this program use program IC that used in the project. This software support all PIC from all version and in this software, the program will be easy when write in C or C++ language. In general this software will support for Intel processor only because this software has been design by for these processor. This software easy to use than others because the programming language is direct and the user did not need to set configuration and to include the library for PIC because it is build in.

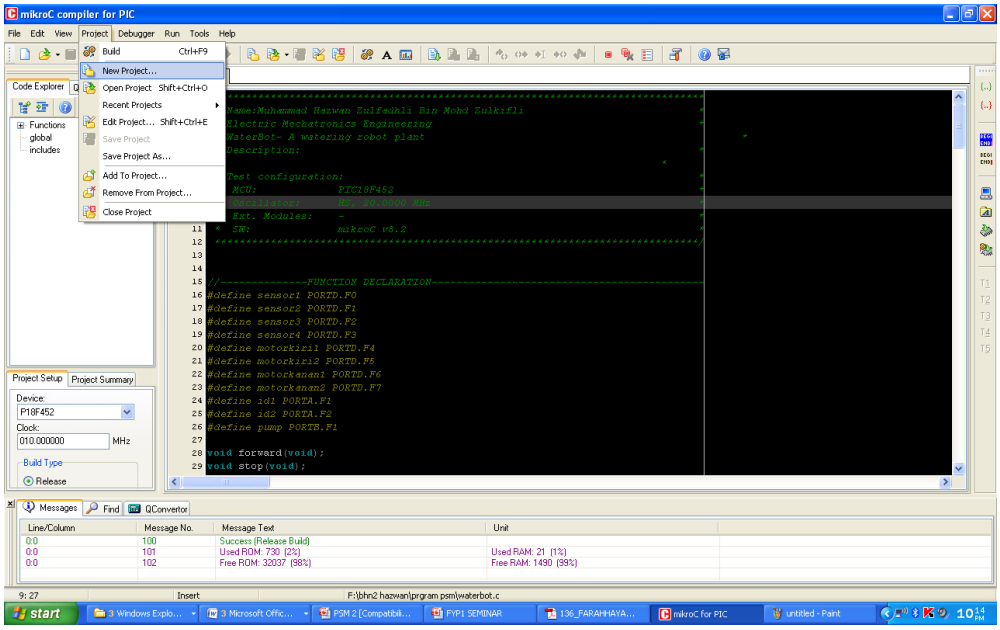

Figure 3.29: Micro C Step 1

Figure 3.29 show the first step to write the programming by using Micro C. That step is click project and new project to begin write programming. If the user click file and new file, the user still able to write the program but after the user build the project by click project and build, the Hex file will not appear and user will not able to burn the program to the PIC. Hex file is the most important file for the user to burn the program into PIC.

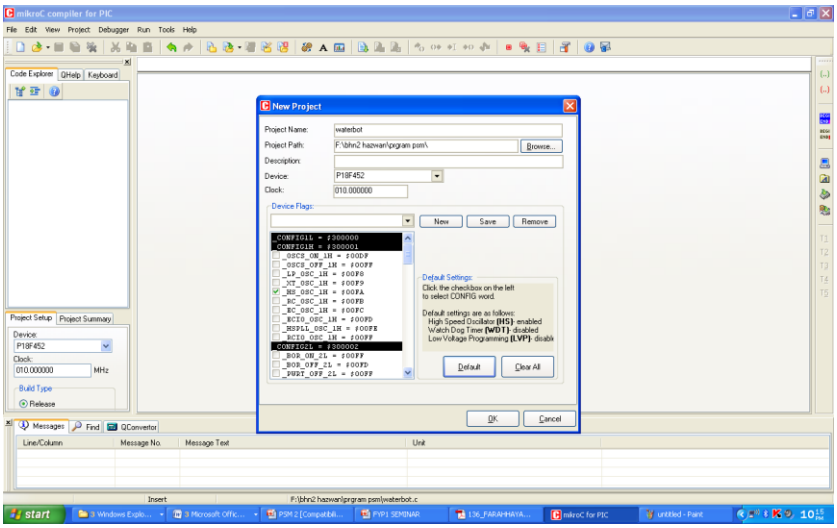

Figure 3.30: Micro C Step 2

Second step after build new project are set the PIC configuration. Figure 3.30 will appear after the new project icon click. The configuration on the PIC must be set like the type of PIC that used, the crystal clock, project name and the device configuration must set to default so that the PIC able to read the programming. If the configuration for the PIC is wrong, the program still able to build but when the program burn to the PIC, it will not able to read and the program is not functioning.

3.4.3 Project Programming

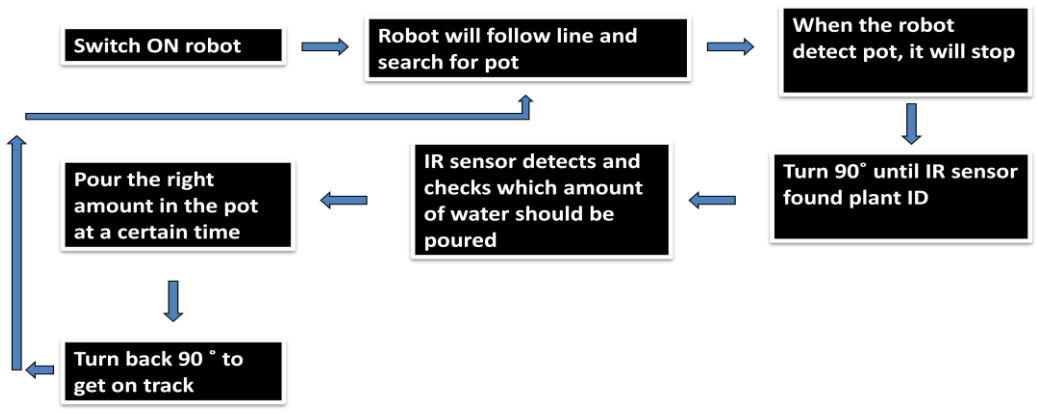
Switch ON robot
Robot will follow line and search for pot
When the robot detect pot, it will stop
Turn 90˚ until IR sensor found plant ID
IR sensor detects and checks which amount of water should be poured
Pour the right amount in the pot at a certain time
Turn back 90 ˚ to get on track

Figure 3.31: Programming Flow Chart

Figure 3.31 shows the project programming flow chart where is show algorithm of the robot movement according the situation faced. The programming start with initialization all the port in PIC that need to used as the output and the input. By using PIC P18F452 all port can be use as input or output. In this project PIC port will be used start from port A to port D.Port D are use both as input and output. From pin RD0 to RD3 are uses as input signals from the IR sensors that will read digital signal from the IR sensor to go to the next instruction. Meanwhile for pin RD4 to RD7 are use as outputs for the power window motor controller.Port C used as the power window motor controller input port where port C used as the output to control PWM (Pulse Width Modulator) of power window motor controller that labeled CCP1 and CCP2. The port declaration and instruction programming writing need to refer to the PIC data sheet to make sure the programming readable by PIC.

3.4.4 Programming Burner

Programming burner is the final step in programming part where the programming for project complete, the program need to be burnt into PIC to the robot able to move. It is like the soul for the robot. In this project the programming project burn by using PICKIT2 software where this software is in package with its programmer.

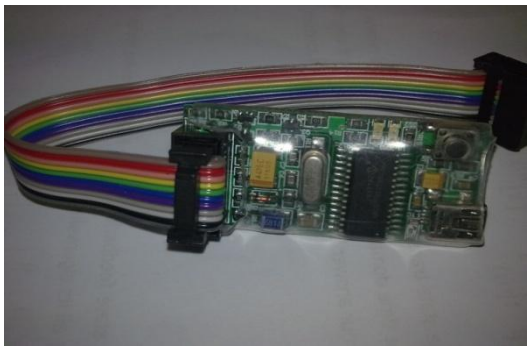

Figure 3.32: PIC Programmer

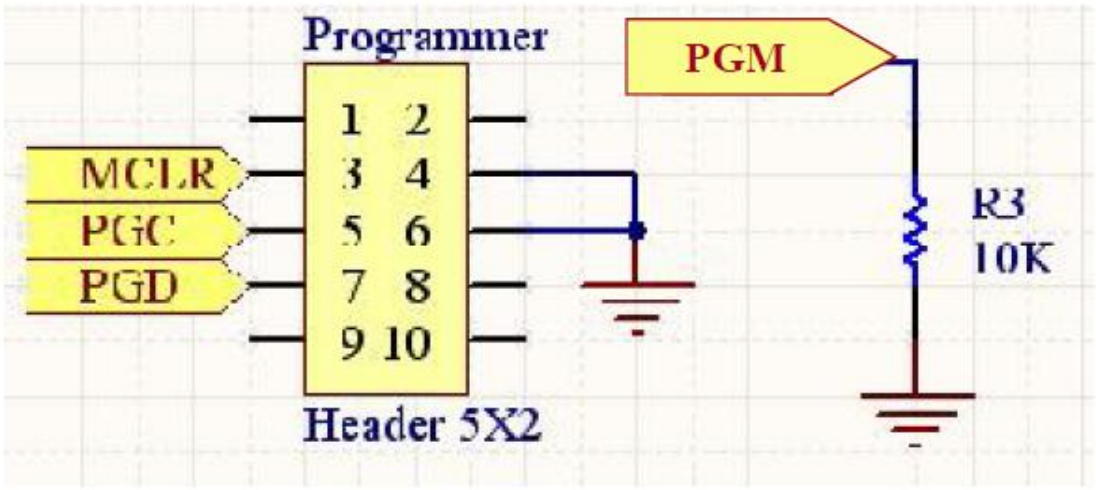

Figure 3.33: PIC Programmer Connection

Figure 3.32 show the programmer that need to use when the programming programmed into PIC. This programmer has specific pin that need to connect to PIC to make sure the programming successfully programmed. The pins that involve connecting in PIC18F452 are pin 1, pin 39 and pin 40 where they are pin MCLR, pin PGC and pin PGD. The pin connection like on Figure 3.33. Before software programmed into PIC, the PIC need to supply a voltage for 5 Volt to power on the PIC. There are two ways to supply voltage through PIC and they are connect the pin 8 in programmer to 5 Volt where the voltage come from computer USB because the output voltage from USB is 5 Volt and the second way is by turn on the voltage from voltage regulator board where the regulator will give the output 5 Volt.

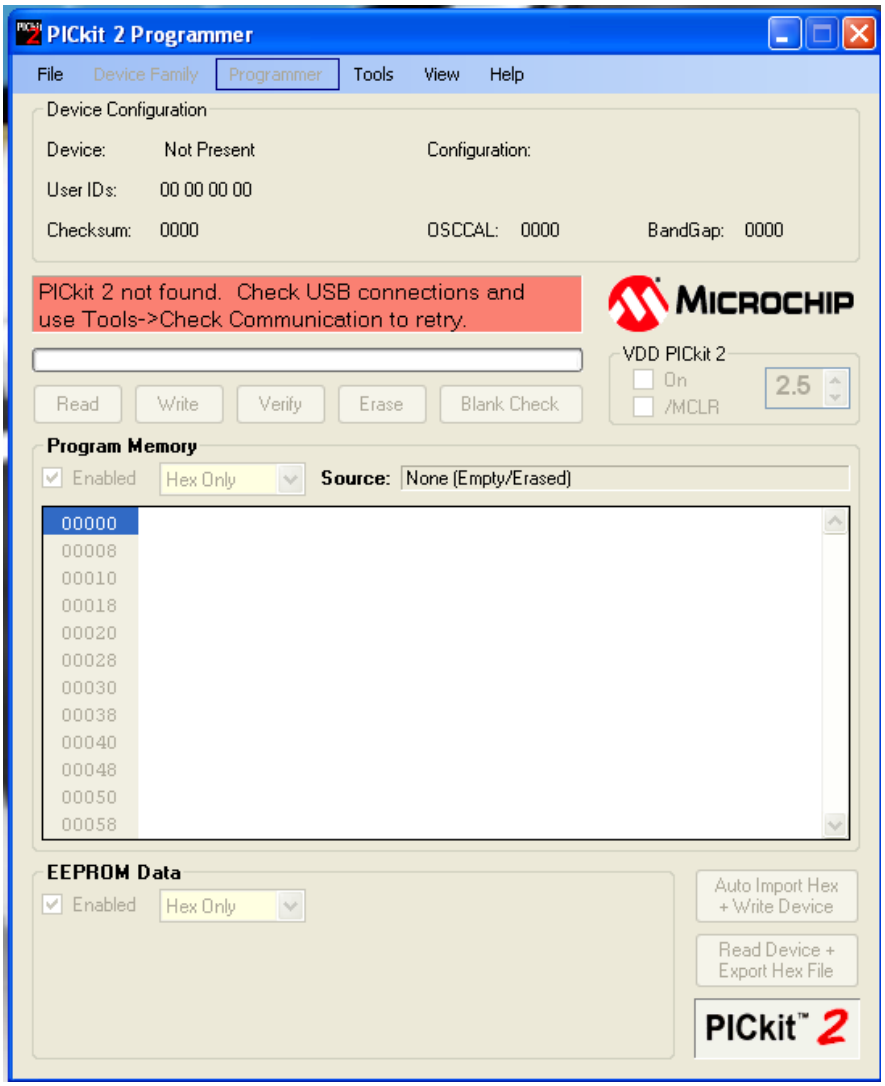

Figure 3.34: PICKIT2 Programmer

Figure 3.34 shows the main window for the PICKIT2 programmer where it is the software that interfaces between the programming in Hex file into PIC. This software easy to use because the user only have to select the file of the programming in Hex file and then click write button on the software to burn the programming into PIC. To check whether the PIC in good condition or not, the PIC series will be display on the PIC type form.

3.4 Conclusion

The mechanical part, electronic part and programming part are the most important combination in designing a robot. Mechanical part represents the body of the robot that should be design and fabricate. This part is vital because it atcs as the backbone of the robot. Without it, the robot doesn't have the suitable body to move or perform its task.

Electronic part is second stage in designing the robot. The electronic circuit is build and design based on the mechanical structure that has been implementate. This is because the space that required to put the circuit can also give effects towards the size and design of the circuit board.The use of IR sensor is vital for the line following, this is the part that makes the robot move autonomously by following the path that have been created. Also the use of relay in controlling the water pump is the main part that makes this robot as the WaterBot.

Last part of design is the programming part where this part is the control processing unit for the robot that act as the brain of the robot. This part is done by programming the integrate circuit (IC) with using a suitable software. In this project will use Micro C to program PIC18F452. The programming part is important to the robot follow the desired objectives. If the programming for the robot is unsuccessful, this may lead to a failure of the design of the robot or the robot itself will malfunction. For conclusion, all parts are related and important to each another and if even one part fails to be completed, this could cause a failure in the robot fabrication.

CHAPTER 4

RESULT AND DISCUSSIONS

4.0 Introduction

The final accomplishments and results of the project shall be explained in this chapter. This chapter discusses on the result, analysis and problems that are encountered throughout the completion of the WaterBot. After the development and completion of the WaterBot, it will then be evaluated in order to measure the effectiveness and to ensure whether it had met the outlined objectives successfully. By the methodology as discussed in the previous chapter, this project has made remarkable result and achievement.

4.1 Result

The WaterBot was successful designed. The robot was able to move according to the line following and even could water the plants that are in pots. But the implementation was not really success; the robot couldn't differentiate the variety of pots that need to be watered due to hardware and software problem.

The first objective of the project was to build a robot that is autonomous by using line following method. This part was successfully achieved without any defects. The robot could move according to the path that was created for the demostration. It had seven movements that were specially created for the demostration. There are forward, stop, little turn right, big turn right, little turn left, big turn left, path finding and 90^{o} turn. For each of this movements has its own identification of the line following. The forward, stop, little turn right, big turn right, little turn left and big turn left movement are used during the robot is on track. Meanwhile path finding is used when the robot is out of track and 90^{o} turn is used to water the plants.

The second objective is to build the IR sensor that can be used to differentiate each pot. To achieve this objective, an IR sensor module was bought to make it easier to apply to the robot and to consume less spend to build an IR sensor. The IR sensor fullfill the specification to detect different dots as an ID for each different pots. But due to hardware and software problems, the IR sensor module couldn't communicate with the PIC microcontroller.

The last objective was to make the WaterBot can water plants in pots. This last objective was the main objective for this project. As discuss in previous section, a DC water pump was used to act as the tool to water the plants. This objective was also encountered with just a little problem but it still could be achevied and implemented in the WaterBot.

4.2 Discussion

This project has not been without any challenges, which are predominant in the undertaking of such an assignment. The first challenge that was encountered in this project was the mistake of designing the pump controller of the water pump. The design of the pump controller was using a SRD relay. In the early stage of designing the pump controller, three voltage source was use to make sure the relay could work. But due to some mistake in understanding the concept of the relay, then only two voltage source was use to implement the pump controller. At last the pump contoller did work as it was planned.

The second problem was related to the second objective that was to build the IR sensor that can be used to differentiate each pot The IR sensor module that was used didn't give the expected result. To overcome this problem, the robot could still differentiate the pots that need to be watered by putting different signs at the path of the line following at each different pots. Other than that, the programming part was also a crucial part to make sure the robot could differentiate each pot. After each sign that it reaches at each pots, the programming will keep in its memory by using the looping method This will help the robot to make sure it can differentiate each pots. But during the demostration, due to hardware problem that was caused by the castor wheel, only one pot could be used to show the detectation of different pot.

The watering process did achieve the mininum standard that was needed in this project. Eventhough there was no mechanism used to be implemented for this robot, only by using gravity of earth, it did water the plants. The only disadvantage for this kind of design is that the watering process could be control which way it should pour the water from the robot. It only has one direction in watering the plants.

4.3 The Final Product

As result of the project, below are the pictures of WaterBot from different views. If noticed, the is a white box in front of the WaterBot, that box is used to stablize the movement of the WaterBot and to make sure it doesn't trembles during its movement. Meanwhile the hanger is use to shape the pipe for the watering process.

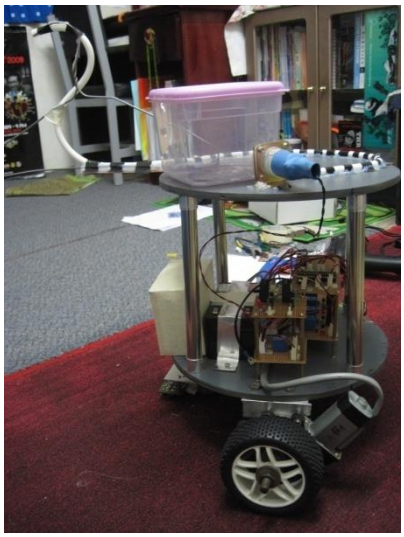

Figure 4.1: Side View of WaterBot

Figure 4.2: Front View of WaterBot

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

There were three objectives in this project that need to be achieved. The first objective was to build a mobile robot that would move autonomously using line following and IR sensor. This first objective was successfully achieved without any problems. The second objective was to build a IR sensor that could differentiate each pot for different type of watering. Due to some technical problems, the IR module sensor that was build could not be use with the PIC that was used. So to overcome this problem, the identification of different pots was done in the programming itself. The robot itself with the help of the different signs that was put at the line following of each nearby pot will be able the robot to identify the different pot that it encountered. The last objective was to build a robot that could water the palnts in pots. This objective was also successfully achieved. The robot did and can water the plants with the use of the water pump that was implemented with the robot. Controlling the pump by using a relay was the simplest way to make sure that this robot could water the plants

In conclusion, due to some technical problems, the second objective couldn't be achieved successfully but it managed to be solved in other way so that the robot

could also differentiate the pots. Eventhough, the main objective that is to build a robot that can water plants in pots are totally achieved. It is a robot that could water plants even so only plants that are in pots.

5.2 Recommendations

Since the pump that was use is small, it could be better for future project that the pump is design to make a bigger pump so that the amount of water that could be pour can be more larger. For this project, the pump was bought at a second hand shop. So any modification to make the pump could pour larger amount of water during the watering process could be a bit dificult.

The position of the motor that was attached to the robot should be more balance. This is because the weight of the robot could make the movement of the robot be unstable. This was a problem for the robot in the early stage of designing. To solve the problem, there was a box of stone was put in the front of the robot to make it more stable while it moved.

The used of more IR sensor could be applied in future project so that the robot could be more intelligent during its line following process. In this project, only four IR sensors was used. With more IR sensors as the detection for the line following, it could encounter more different movement for the robot.

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7. International IOR Rectifier IRFZ48N Datasheet.

8. IR01A User Manual.

9. Microchip, PIC16F87XA Data Sheet.

APPENDIX A

WaterBot – A Watering Robot Plant Program Using Micro C Programmer

```
/*****************************************************************
*************
 * Name:Muhammad Hazwan Zulfadhli Bin Mohd Zulkifli
*
 * Electric Mechatronics Engineering                    *
 * WaterBot- A watering robot plant                         *
 * Description:                                    *
                                                *
  Test configuration:                                *
 *  MCU:            PIC18F452                          *
 *  Oscillator:     HS, 20.0000 MHz                        *
 *  Ext. Modules:    -                                 *
 *  SW:            mikroC v8.2                          *

*****************************************************************
**********/


//--------------FUNCTION DECLARATION----------------------------------------
#define sensor1 PORTD.F0
#define sensor2 PORTD.F1
#define sensor3 PORTD.F2
#define sensor4 PORTD.F3
#define motorkiri1 PORTD.F4
#define motorkiri2 PORTD.F5
#define motorkanan1 PORTD.F6
#define motorkanan2 PORTD.F7
#define id1 PORTA.F1
#define id2 PORTA.F2
#define pump PORTB.F1

void forward(void);
void stop(void);
void turnrightsket(void);
void turnrightbyk(void);
void turnleftsket(void);
void turnleftbyk(void);
void turn90(void);
void cariarah(void);
void pumpair(void);
void idpokok(void);

void main()
{
//--------------------DECLARE PORT-----------------------------------------
  ADCON1= 0x0F;
```

```
  trisa = 0b00001111;
  trisd = 0b00001111;
  trisc = 0b00000000;
  trisb = 0b11111000;

//---------------------MOTOR CONTROL REGISTER----------------------------------
    PR2=255;
    CCP1CON = 0b00111100;
    CCP2CON = 0b00111100;
    PORTD   = 0x00;
    T2CON   = 0b00000101;



//-----------MOTOR MOVEMENT CONDITION-----------------------------------------

       while(1)
       {
         if ((sensor4==0)&&(sensor3==1)&&(sensor2==1)&&(sensor1==0))
         {
          forward();
         }
         else if ((sensor4==1)&&(sensor3==1)&&(sensor2==0)&&(sensor1==0))
         {
          turnleftsket();
         }
         else if ((sensor4==0)&&(sensor3==0)&&(sensor2==1)&&(sensor1==1))
         {
          turnrightsket();
         }
         else if ((sensor4==1)&&(sensor3==0)&&(sensor2==0)&&(sensor1==0))
         {
          turnleftbyk();
         }
         else if ((sensor4==0)&&(sensor3==0)&&(sensor2==0)&&(sensor1==1))
         {
          turnrightbyk();
         }
         else if ((sensor4==0)&&(sensor3==0)&&(sensor2==0)&&(sensor1==0))
         {
          cariarah();
         }
         else if ((sensor4==1)&&(sensor3==1)&&(sensor2==1)&&(sensor1==1))
         {
          stop();
          turn90();

         }
       }
```

```
}

//-------------------MOTOR DRIVE FUNCTION-------------------------------------
//--------------FUNCTION FORWARD-----------------------------------------------
void forward(void)
{
motorkiri1=1;
motorkiri2=0;
motorkanan1=0;
motorkanan2=1;

CCPR1L=120;
CCPR2L=120;
}

//--------------FUNCTION STOP--------------------------------------------------
void stop(void)
{
motorkiri1=0;
motorkiri2=0;
motorkanan1=0;
motorkanan2=0;

CCPR1L=0;
CCPR2L=0;
delay_ms(5000);
}

//--------------FUNCTION TURNLEFTSKET------------------------------------------
void turnleftsket(void)
{
motorkiri1=0;
motorkiri2=0;
motorkanan1=0;
motorkanan2=1;

CCPR1L=60;      //ccpr1l tuk pwm kanan
CCPR2L=0;

}

//--------------FUNCTION TURNLEFTBYK-------------------------------------------
void turnleftbyk(void)
{
motorkiri1=0;
motorkiri2=0;
motorkanan1=0;
motorkanan2=1;

CCPR1L=80;      //ccpr1l tuk pwm kanan
```

```
CCPR2L=0;

}

//--------------FUNCTION TURNRIGHTSKET-----------------------------------------
-----
void turnrightsket(void)
{
motorkiri1=1;
motorkiri2=0;
motorkanan1=0;
motorkanan2=0;

CCPR1L=0;
CCPR2L=60;

}

//--------------FUNCTION TURNRIGHTBYK------------------------------------------
----
void turnrightbyk(void)
{
motorkiri1=1;
motorkiri2=0;
motorkanan1=0;
motorkanan2=0;

CCPR1L=0;
CCPR2L=80;

}

//--------------FUNCTION CARIARAH----------------------------------------------
void cariarah(void)
{
motorkiri1=1;           //akn pusing ke kanan
motorkiri2=0;
motorkanan1=0;
motorkanan2=0;

CCPR1L=0;
CCPR2L=70;

}

//--------------FUNCTION PUMPAIR-----------------------------------------------
void pumpair(void)
{
    pump=1;
    delay_ms(5000);
```

```
}
//--------------FUNCTION IDPOKOK-------------------------------------------------
void idpokok(void)
{
          if((id1==1)&&(id2==0))
          {
            pump=1;
          }
          else if((id1==0)&&(id2==1))
          {
            pump=1;
          }
          else
          {
            pump=0;
          }

}
//--------------FUNCTION TURN90--------------------------------------------------
void turn90(void)
{

    motorkiri1=0;
    motorkiri2=0;
    motorkanan1=0;
    motorkanan2=1;

    CCPR1L=80;      //ccpr1l tuk pwm kanan
    CCPR2L=0;


    if ((sensor4==1)&&(sensor3==1)&&(sensor2==1)&&(sensor1==1))
    {
      pump=0;
      delay_ms(5000);
      pump=1;
    }
    else
    {
       cariarah();
    }
}
```